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THE ECONOMICS OF CONNECTIVITY
by Jerry Michalski

Some things on the Internet seem too good to be true: Stay online all the time for $15 a month! Get free, unlimited e-mail and pay no extra charges for long-distance communications! As if to balance those good things, the Net has more than its share of congestion and service disruptions.

These offers and problems aren't simply the results of rapid growth, loss-leaders, free-rider syndrome or even the short-lived dreams of some altruistic souls. They are symptoms of the interaction of a physical infrastructure poorly matched to the pricing models, architecture and regulatory environment of the superstrate evolving above it.

Some physical resources are mispriced, which leads to bottlenecks. Other resources are used in new ways, creating repercussions through the system. Pricing tends to move faster than physical supply, but in the long run supply adjusts to eliminate bottlenecks and pricing reflects supply. Things keep moving....

The Net is hastening the co-evolution of today's communication systems so that physical infrastructure, traffic patterns, application requirements and revenue flows will complement each other better. The basis for competition -- and profitability -- is shifting quickly in this newly fluid market. As Nicholas Economides, professor of Economics at NYU's Stern School of Business, says, "The communications revolution is eliminating many bottlenecks where companies used to make money."

This issue of **Release 1.0** focuses on the co-evolution of the existing carriers (principally the phone and cable TV companies and their physical systems) and the emerging Internet superstrate, which behaves more like an ecosystem than the predictable mechanism of equilibrium economics.

Currently, US local-exchange phone companies are feeling the most pressure from the Internet, which flips their business model upside-down. To long-distance carriers, the Internet offers a way to bypass the local carriers and sell integrated, higher-level services (not merely Internet access) to homes and businesses. Cable TV system operators have the physical infrastructure best suited to Internet- ⟹

PC FORUM: MARCH 17-20 IN TUCSON

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style services, but they have been slow to see the opportunities. This market is theirs to lose. Internet service providers are causing the new system pressures. They bring new pricing, interexchange and service models that affect all the other players.

The companies that do best will be those that adopt the new business models deeply and quickly and redeploy their resources accordingly. Today's core assets or skills may turn out to be tomorrow's albatrosses -- or eagles. In fact, today's physical communications infrastructure is poorly configured for the kinds of traffic it will eventually have to carry. Although some players stand to lose more than others over the next few years, none is especially advantaged today. All of them will have to make substantial investments to take advantage of this opportunity.

The last two sections of this newsletter address two other key issues: Whether these new revenue and business models are stable over time, and whether there is (or could be, in the near future) enough communication capacity to meet demand. A future of unstable economics and constantly scarce capacity will be dramatically different from one of stable payments and abundant capacity. We believe current trends point toward robust stability and abundance spiked with plenty of turmoil over the next few years, despite the many potential show-stoppers along the way.

SQUEEZED

The sudden and growing popularity of Web surfing, audio and multimedia capabilities and full-time Internet connections has not only stressed the Internet, it has also heightened the pressures on traditional communication carriers, whose infrastructures the Net rides in ways not planned for by telecom-system designers.

Why online access drives the local phone companies nuts

When you make an analog phone call, you tie up a port at your local phone company's central office. The LECs estimate aggregate usage to decide how many ports to install for a particular local population. Log in with your modem and leave it on all day, and you've just screwed up all the statistics and exceeded your "fair share." You've also tied up dedicated assets, and if you live in an area with unmetered local calls (as most of the US does, minus substantial parts of Ameritech's territory and New York City), the phone company gets no additional revenues. ISDN calls also tie up ports.

Some LECs have tried to charge differently for modem calls, with little success. Most of them would also like to move to metered local rates, but competition, real and threatened, is likely to keep that from happening.

The businesses most threatened by the Internet today are the local phone companies (also known as local-exchange carriers or LECs). To many LEC executives, the Internet must feel like a cancerous growth that is eating away at the traditional (and stable) telecom system and that will eventually destroy itself -- probably by killing its host.

The Internet doesn't play by the rules. It exploits the worldwide phone network's every weakness. It motivates individuals and companies to stay logged on all day, which ties up phone companies' expensive fixed assets without bringing incremental revenues. It treats the phone line as a blind conduit to the nearest point of presence, which masks all information about subscriber behavior. It substitutes e-mail for the long-distance voice traffic that helps pay for the infrastructure's fixed costs. While doing so, it avoids local-access fees (which are an enormous revenue source) and regulatory requirements (which keep competitors out and legal fees high).

Tired: sessions; Wired: connections

Many of the assumptions and business models that the phone infrastructure was designed around are no longer useful. The controlled market for which phone companies engineered their systems, with its short, timed "sessions," virtual circuits and itemized retail payments, is becoming irrelevant as companies and individuals increasingly buy full-time "capacity" on packet networks at wholesale prices. Phone companies are used to reselling capacity to other phone companies and to large corporations, but the designers didn't count on everyone becoming a wholesale customer. It upsets everything from tariffs to legislation and service offerings.

They also didn't count on the effects full-time connections would have on the phone system's physical and software infrastructures. In a world of full-time connections, centralized switched systems with dedicated resources are less efficient than distributed, LAN-like systems that share resources.[1] And the billing systems that are designed for a retail, session-oriented world will have to be put to different uses in this new world. Rather than bill for fractions of minutes spent online, these systems may be transformed to bill for small portions of content or goods and services, though they may not be that flexible.

Take your marks

All is certainly not lost: The restructuring underway presents business opportunities for local-exchange carriers and others. Some LECs have jumped into the fray, most notably PacBell, which is working hard to make Internet access simple and affordable in California. Long-distance carriers such as MCI have been participating for some time: They provide the long-haul trunks that other Internet service providers (ISPs) lease to move bits across the country. They have also begun to offer Internet services of their own directly to corporations and consumers, a market of intriguing opportunities (see box, next page). Yes, their long-distance revenues are threatened, but not for three to five years.

Cable TV system operators don't currently provide any Internet transport for others and offer an insignificant amount of direct Internet service, so

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1 *This all leads back to fundamental debates about packet and circuit switching, which pit the packet model's efficient use of bandwidth, low cost, high reliability and variable latency (no guarantees on when the bits will arrive) against the circuit model's real-time (low, predictable latency), high-quality, high-availability communications.*

they haven't felt the Internet's effects yet -- nor have Internet providers felt their effects. Until recently, cable operators were pursuing interactive-TV and video-on-demand projects (and, frankly, they were well on their way to replicating Prodigy's original near-disaster by creating inflexible, one-way bit-delivery systems). Now they've begun to wake up and sniff profits on the Internet. TCI and Kleiner Perkins' joint venture @Home is building an Internet protocol-based network for residential service. Cox Cable, Time Warner and several others have recently announced plans to jump in, too.

Access fees, bypass and a little loophole

US long-distance phone companies (also known as interexchange carriers or IXCs) pay a series of access fees to local-exchange carriers that amount to roughly 44 percent of IXC gross revenues. Needless to say, they're tired of this arrangement and have been searching for ways to bypass the local carriers. MCImetro, the local-bypass subsidiary that MCI formed in 1994, is one such initiative.

Interexchange carriers pay access fees only on so-called basic services such as voice phone calls. Because Internet access is considered an enhanced service, it offers IXCs a convenient way to sidestep those fees. In principle, IXCs could offer high-quality telephony over the Internet and completely avoid the access fees. Of course, doing so would require substantial improvements to the Internet's infrastructure and would probably provoke legislative intervention, but it's the most promising strategy available to bypass players today. All of this should drive access fees down. If the local-exchange carriers balk, they will create new incentives for cable TV and utility companies to offer competitive local access.

New game, new goals, (relatively) open field

The Internet has accelerated industry changes that were already under way. Many states have opened their telephone systems to competition, often at the initiative of the local phone company, which was trying to get into long distance or cable TV. The revised Communications Act now in Congress will open markets even further (though it hardly touches access fees and Internet connections); competition may do so anyway. Regardless of its details, almost everyone wants it passed in order to get on with business. However, its censorship provisions could severely hamper growth if they aren't quickly overturned. International phone companies are looking at each other's markets, as are phone and cable TV companies and competitive access providers in each market. All are potential allies or competitors.

But the goals have changed. The new weaponry is integrated services of a different kind -- not the kind envisioned by the designers of the Integrated Services Digital Network (ISDN) and the Advanced Intelligent Network (AIN) that ISDN is part of. The relevant service platform is now up a few layers in the protocol stack, atop the Internet's TCP/IP. IBM's Internet champion John Patrick refers to it as the application space.

This space lies above the capabilities of today's Internet and includes services previously in other categories such as unified messaging, group-

ware, computer-telephone integration and multiparty conferencing. Although the public Internet handles phone calls and broadcast TV signals mostly as experiments, private internets are close to offering those capabilities as real services (see Precept Software, page 7, and OnLive!, **Release 1.0**, 11-95). The company that designs its systems to offer these services atop an Internet-style platform will end up holding its customers' mailboxes, Web pages and more. (It's much harder to switch carriers when you have to move your online address book instead of merely endorsing the $50 inducement check.) Companies don't need to be large or to own physical infrastructure to win this game; also, barriers to entry haven't been erected yet, so expect more entrants.

However, a service-platform change this profound will take time. The Internet must evolve significantly for such capabilities to work satisfactorily (more on this in a moment). For many years to come, the retail phone call will remain the principal model for communication -- but the action will be on the Internet. There's plenty of time for companies to jump in and become the integrated service providers of the future. The key is whether and how quickly they can abandon some old assumptions, and how well they can leverage their core competencies and assets. Changing their assumptions may help them reassess their skills and assets.

Ready for prime time?

Over the past 25 years, the Internet has grown quietly to become the most useful and interesting distributed application platform around. It has done this with some US Government seed money, but without government- or state-granted monopolies (which brought us universal phone service and local cable TV systems) and without market domination by one company.

Two years ago, before the Web hit, the Internet was an intramural network kept by custodians with a shared interest in improving the medium. The companies that ran the backbone acted as suppliers; the pioneers selling commercial access built their markets slowly. Now most of the custodians have been hired by companies aspiring to initial public offerings of Netscape's magnitude, or their old companies have been acquired or gone public themselves.

Despite the usual incentives for carriers to create lock-in around their technology or services, there are even more powerful forces at work to foster interoperability. It also behooves participants to see the Net evolve coherently. For now, Internet telephony products are all incompatible, just as in the early days of the telephone, when small phone companies didn't connect with each other. But it is in the carriers' and users' interests to use common standards so they can offer these advanced features to broad audiences.

The Internet is like a sourdough starter: Individuals can make different kinds of bread with it, but it behooves the community to see that the starter isn't ruined. Some experimental breads may not sell, but their batter will be thrown away rather than corrupting the main batch of starter. Really successful experiments may be added to the main batch, but only after careful consideration.

Coherence doesn't imply institutionalization or homogeneity. Many people would welcome more structure or at least transparency in this market, but

few people want to extinguish the creative spark that has brought so much recent innovation to the medium.

The Internet will probably remain a loosely coupled confederation built from collaborative efforts and gentlemen's agreements such as the peering arrangements by which many carriers exchange traffic without billing each other for it. There are pressures to make the system work more "efficiently" (of course, each company has its own idea of what that means), but few companies want to replicate the cumbersome structures of the ISO data-networking world. Instead, the loose process will continue, and new industry associations or consortia will likely emerge to increase the level of coordination in specific areas. It turns out that the seeming chaos is actually self-organizing and quite efficient (see **Release 1.0** 6-89 & 4/5-92).

Room for improvement

The Internet is held together with baling wire and spit -- and plenty of old-fashioned human effort. It's barely ready for the extraordinary growth it is now seeing. Servers are often mysteriously unavailable. Major interconnection points crash and knock entire services off the air for hours. Packets that need to travel only a few miles may travel across the country. Routing tables are ready to burst, which makes interconnections more difficult. Constant route changes devour router capacity. The Internet Protocol itself (the IP in TCP/IP) needs overhaul to extend the address space, allow for priority settings and more. It's atop this relatively fragile platform that companies would like to field high-performance services such as real-time voice and video.

High-availability servers, redundant links and other solutions invented in the mainframe era can solve some of these problems. Others require advances in Internet technology. To address these issues, technical workgroups have created standards such as CIDR (Classless Inter-Domain Routing, pronounced "cider"), a near-term fix to some of the routing problems; IPv6 (IP version six, also known as IPng or "next generation" IP), the longer-term answer; RSVP (the ReSource reserVation Protocol), which allows applications to request and hold bandwidth; and RTP (the Real-time Transport Protocol), which encapsulates and manages real-time datastreams. There are also ways for the phone and Internet infrastructures to work together more efficiently. The phone companies are developing On Demand Routing, which can initiate direct ISDN links when Internet service quality is inadequate.

Though this long list of protocols won't fix all the Internet's problems,[2] it will add capabilities that include real-time session management, better multicasting and route aggregation. Thus armed, service providers will be better able to tackle peak-load congestion problems, discourage abusers and selectively offer time-sensitive and other priority services.

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2 *Other frontier research areas for the Internet include next-generation router/switches, more scalable routing tables, system-wide load balancing and system management, among other topics. As developers increasingly perceive the Internet as an ecosystem, they will probably gain many insights from neural, fuzzy-logic and other adaptive systems (see Release 1.0, 4/5-92, 6-89).*

Corporate intranets are great places to begin using such protocols. For example, one astute company working to commercialize RTP and related protocols in corporate settings (for now) is Precept Software, a networking startup founded by Judy Estrin and Bill Carrico, the husband-and-wife team that previously founded Bridge Communications and Network Computing Devices. In the first quarter of 1996, Precept expects to begin selling software that makes corporate LANs smart enough to do real-time multimedia communications, kiosk and training systems, and more.

Looking ahead

In the year 2000, Internet service providers probably won't have much of their own fiber, cable or twisted-pair wiring; they will have strong customer recognition. They'll provide online and telephone support, send bills and collect payments. In many cases, they'll offer special services to their customers only. If the Internet can get past the baling-wire-and-spit stage to the year 2000 (and we believe it can), it will probably look like the description on the next page.

That service scenario isn't a particularly aggressive vision. It's already happening in small markets and on private networks, but mostly as prototypes. By the year 2000, we expect such offerings to be commonplace.

Potential show-stoppers

Several battles loom as the Internet changes and as commercial interests jump in. Here are some of the most significant ones.

Government censorship. Congress could successfully pass the current Communications Decency Act, making ISPs liable for the content of traffic they normally don't inspect and creating huge new costs for them (Congress wouldn't do that, would it?). Other countries have begun to flinch at the Internet's uncontrollable content and unfettered, low-cost access.

Telecom backlash. Phone companies are phenomenal lobbyists. They could promote legislation that limits market entry directly or requires ISPs to provide a series of costly features or services, such as detailed cost accounting. Local-exchange carriers might try to get the enhanced-services loophole closed, so Internet carriers would no longer be exempt from paying access fees. Or phone companies might try to constrain access to high-performance leased lines, thus throttling the Internet.

Competitive lock-in and market fragmentation. Monopoly profits are incredibly attractive. Carriers who get large audiences or deliver unique services might try to block access to others and set off on their own. Or they could try to lock other participants into their proprietary standards, then break away.

Internet process breakdown. Internet video or other technologies could strongly change the symmetry of transmissions and contribute to the breakdown of so-called peering agreements (see page 12).

Nevertheless, we remain optimistic. Government intervention can clearly slow the Internet down, drive parts of it underground and raise its costs,

Service plan, year 2000

In the year 2000, the phone, cable and Internet infrastructures are quite intertwined, but not identical. They share some physical networks and keep others separate. For example, TV broadcasts still travel over private networks by air or cable: Internet service providers won't accept the torrent of one-way bits from broadcasters. However, much TV channel-switching and product ordering occurs over Internet protocols, often as a separate "channel" over the cable systems themselves. Internet telephony has taken a substantial share of the traditional telephony market in the US.

The Internet-based communications landscape has evolved several logical layers, which form the basis for extra-cost service offerings. (The same physical networks can provide multiple logical networks, each with different access speeds, grades of service and prices.) Here is a typical service plan that offers three levels of service.

Regular access service is a "best-efforts" offering not much different from today's Internet (although it runs IPv6). It offers inexpensive, flat-rate, distance-insensitive, narrowband connectivity (up to ISDN speed). It offers no quality of service or delivery guarantees; people who don't mind the occasional busy signal or lost message and want low prices love the service. This market tier has extremely low barriers to entry: Practically anyone can become a service provider of this kind and hook in to the Internet.

Premium-service communications are routed expediently as packets over the public Internet as well as the service providers' private networks (which may have physical capacity leased from other carriers). The public and private systems run the same protocols and are richly interconnected; when the public Internet is clogged, Premium traffic automatically shifts to the private network.

Premium-service customers pay for guarantees (of priority, delivery, availability, timing and privacy) and for higher-speed access, the ability to indulge in heavy one-way traffic and special services such as unified messaging, telephony and video services. The special-service costs are usually low: They only kick in when they are needed, and even then, only in cases when customers turn them on. For example, if there's network congestion, e-mail messages that can wait get delivered when the congestion clears up; urgent ones get sent right away, for an extra fee.

Super-service packets travel exclusively over private networks. This service option is faster than the others because it's provisioned, tuned and monitored carefully by a single carrier (or multiple carriers with special agreements). Super customers get features not available on the public Internet, such as integrated music, TV and movies; stereo, CD-audio-quality, multi-party telephony; jitter-free videoconferencing; and other great services.

but governments probably can't completely stop the Net without closing down the phone system and confiscating all the computers. So far, competitive forces are strong and the Internet's resiliency and creativity seem unharmed -- perhaps even enhanced. Economic incentives abound, yet no single competitive group is especially advantaged.

The quiet but powerful influencers of the Internet's evolution are corporations outside the technology and media industries, especially financial institutions and multinationals. Many of these companies see the unique value the Net brings, especially in changing their relationships with their stakeholders. Over the past couple of decades, corporations have tasted (and paid for) the traditional, proprietary processes -- the incompatible proprietary-system approach and the cumbersome, expensive (and still incompatible) ISO-standards approach -- which failed to deliver a useful, ubiquitous infrastructure. These companies are likely to lead the drive toward continued openness and higher performance.

FOLLOW THE VALUE

To a large number of its users, particularly those in universities and corporations, the Internet seems free. It's not. The payments that make the Internet continue to run were paid through taxes and are now often hidden as tuition, phone service or overhead, but they form a food chain that has worked quite well so far. Individuals and organizations using the Internet generally pay for their own connections upstream (to service providers with more capacity).

Communication-link upgrades have historically required substantial capital investments -- budget-eating gulps. Plotted, the upgrade path options looked like a steep step function. Through increased competition and services with more fine-grained pricing options, that slope is gradually getting smoother and less steep. Also, flexible, low-priced gear is becoming available. Nevertheless, even a simple connection can be an ordeal to select and install (just ask us about the new 56 Kbps line at EDventure!).

There are still some major cost items. For example, upgrading from a T1 to a T3 connection (from 1.5 Mbps to 45 Mbps, the fastest connection in common use on the Internet today) means moving from copper wires to coax or fiber in the local loop, which can be prohibitively expensive for many businesses. There are discontinuities at lower levels, too: Moving from basic-rate ISDN to primary rate ISDN (from 128 Kbps to 1.5 Mbps) requires considerable new equipment and labor.

Sunk costs and shared resources

General-purpose computers connected to the Internet are superb shared resources. They cost much more than telephones, but once they've been installed they can serve many tasks at once, including for other machines or users downstream. And until they run out of capacity, using them incurs negligible marginal costs. Since many of these machines will already be cost-justified as word processors or mainframe front-ends, it is tempting to think of them as sunk costs. Even allocating the real costs of connectivity to a multi-purpose machine leads to low per-task overhead.

The Internet is a cost accountant's nightmare. Everything serves multiple purposes. Traffic of extremely different types and values can move through the same device. Incremental costs are visible only when a device or connection is overloaded. Worse still, on the Internet, almost everyone is blind: Users can't predict the consequences of their actions, service providers can't identify what they're carrying and network managers can barely take the system's pulse (see box).

Internet auditors are no happier than the accountants. Just about anyone with technical and business skills can become an ISP. The smallest ISPs have little accounting capability. Some of the largest are probably trying to buy market share, so their pricing can distort the market's true underlying costs. Surprisingly, the phone companies are practically unauditable: They have adapted to the strange distortions of their heavily regulated environments by taking advantage of all the loopholes. Many of their fees and prices are historic artifacts far removed from the actual costs of providing the underlying services. These are the weaknesses that the Internet is preying on.

Customer pricing: Did we say it was a T1?

In general, carriers and ISPs sell the *potential* to move a certain number of bits per second, but count on the actual flow of bits to be far lower. ISPs then aggregate that flow across multiple customers and hope they don't all need peak capacity at the same time. This is similar to the way phone companies calculate how many ports a switch must have in order to serve a given number of residential telephones. For small individual customers, this is all part of the etiquette of dealing with your service provider: You are expected to be considerate about disk space and access time.

Customers who concentrate or aggregate others' traffic mess this system up because they drive usage toward a connection's full capacity. In order to control that and keep traffic predictable, ISPs usually forbid their customers to resell capacity. In fact, most ISPs oversell their capacity themselves. They have one or two T1 links upstream, yet they sell six or ten T1s to their customers.

There is considerable systemwide pressure to let anyone aggregate traffic from multiple downstream customers, but the underlying technology doesn't yet allow service providers to match costs and revenues. In some cases, carriers may move to precise usage payments, but it is more likely that the Internet will move toward relatively flexible arrangements that apportion costs more closely to usage, with a minimum of additional overhead.

More specifically, by implementing the protocols mentioned on page 6 and others, the Internet is moving toward:

- congestion pricing and
- bandwidth reservation schemes, which will allow carriers to offer
  - multiple tiers of service that include
    - quality of service guarantees and
    - committed information rates.

A committed information rate agreement sets minimum and peak bandwidth boundaries, then measures average usage over a month. If the customer stays below a pre-set volume commitment, there is one price. If over, a higher price. PSInet and other carriers offer tiered prices based on average usage (aggregate traffic from a single customer). This similar to frame-relay pricing in that it involves long-term provider relationships and agreed traffic volumes.

Congestion pricing raises complex issues, which include deciding what to charge for (the video bits or the telnet session), which party to charge (the originator or the destination) and whether and how to account for the charges. Hal Varian at UC Berkeley and Jeff MacKie-Mason at the University of Michigan have written eloquently about this topic and others (see Resources, page 16). Another approach is the real-time resource auctions proposed by Agorics (see **Release 1.0**, 8-94). The price for priority service may vary dynamically based on system loads, but too much subtlety is likely to produce a complex and unworkable congestion-pricing system. More likely, a simple system that allows senders to pay for priority service when there's congestion will emerge. Users like predictable costs (hence, insurance).

As these capabilities emerge, the distinction between wholesale and retail service blurs. Any company can be a reseller, but its supplier will monitor

its patterns and set its fees to roughly match the costs it incurs. This will allow the Internet's organic growth model to filter down to the smallest nodes. At each level, companies will have peers (to their left and right), transit and bandwidth providers (above) and customers (below).

Internet blindness

Unlike most other common communication systems, the Internet has a blind architecture. Users don't know the effects of their actions on the infrastructure. When they click on a simple icon, that action could bring up a Web page with one word on it or it could begin to download a 10 Mb video clip. You go into the cloud and emerge somewhere else.

Because the Internet is mostly connectionless, service providers can barely tell which bits came from where. They can't tell what's inside encrypted or compressed packets, or figure out what role individual packets sent in the clear have within their applications.

Counting things across the Internet is difficult, too. Only system administrators know what goes on behind their gateways and routers. This makes counting the number of Internet users extremely difficult. When the NSFnet was the only backbone, the Internet Society could count wide-area traffic volumes. As more backbone carriers emerge, even that becomes a challenge.

Pricing between carriers: Peering and soft value

When roughly equivalent ISPs meet and exchange traffic, they usually don't account for each bit and bill each other. Instead, they swap bits based on *peering agreements* that assume that each benefits from access to the others. Because the ISPs collect fees from their subscribers and clients, this model is also generally known as *sender keep all* or *bill and keep* (see box).

Two things keep the peering system working: perceptions of value and clear distinctions between peer and customer relationships (the balance of value traded). In other words, knowing whom to swap with and whom to sell to is crucial. This is no simple task.

Value does not map directly to the number of bits exchanged.

Because there's little or no money changing hands between peering ISPs, the process is particularly fascinating and involves many non-monetary variables. In fact, the value in question does not map directly to the number and direction of bits moving. It has to do with the number of subscribers and the kinds services an ISP offers access to, as well as its ability to carry others' traffic to hard-to-reach places.

An ISP that has mostly regional traffic and attracts many visitors might be far more lucrative than a large one whose customers constantly transfer

huge files from distant cities and which has nothing else to offer. What's valuable to one carrier may be insignificant to another, which leads to more bilateral agreements. This is why companies such as AOL, which has many subscribers but offers few services to the rest of the world, have to take care in the way they let their subscribers get on the Internet. They try to train their subscribers, cache documents locally and offer some services to the rest of the Net.

The new peerage

Until the early 1990s, the NSFnet carried all Internet backbone traffic. It dropped slowly to 75 percent in September 1994, then quickly to zero when the NSFnet was phased out in May 1995 and handed over to commercial service providers, who share the traffic. As the NSF withdrew its financial support, ISPs struck bilateral and multilateral arrangements that have held together well -- after a slightly shaky start -- completely free of governmental market controls.

These arrangements are known as peering agreements, and generally involve no cash settlements. Every carrier doesn't automatically peer to every other one at one of the dozen or so interconnection points. Instead, there are many bilateral and multilateral agreements. There is a nominal fee for attaching to the network interconnection points, but little money changes hands unless one ISP is buying transit services from another.

Management cost matters a lot, too. A service provider might offer valuable resources but cause constant headaches. The decision to peer is as much about the capabilities of the requesting system manager as it is about traffic flows. Network administrators are trying to prevent other carriers from inflicting brain damage on their networks -- and getting people angry at them.

"The system administrators have a feel for the traffic. This is not something you necessarily want to build a billion-dollar business plan around."

-- Milo Medin, @Home

Of course, bit volumes do matter, and many of today's peering arrangements will become contracts with payments. A relationship with lopsided traffic should be a supplier/customer relationship. There will also be opportunities for service providers to peer with each other throughout the system.

ISPs in this environment need good judgment about who is a peer (who offers relatively equal exchange of value) and who is a paying customer (who needs your help to connect with others). Today's methods need to evolve, especially as high-performance services arrive on the Internet. Payments are inevitable, but system administrators should avoid relying exclusively on bit-counts (which are flawed measures of overall value) and evaluate their agreements from a broader perspective.

SHORTAGE OR SURPLUS?

All this fuss over advanced Internet services won't matter if there isn't enough capacity to make the system work smoothly.

It's pretty easy to argue both sides of the capacity issue. If you want to say that there will be plenty of capacity, start with the glut of long-haul and local-area fiber capacity,[3] add the slack that exists in the traditional local loop and the new entrants such as cable TV operators who are almost certain to bring new capacity. Multiply this by a technology fudge factor[4] and a booming stock market wanting to invest in the Internet and pretty soon things look good.

The opposite argument is strong, too. You need only point out how there will soon be a shortage of ports at phone company central offices, how available bandwidth is already oversold on trunk systems that are running out of capacity. You needn't mention the fragilities covered on page 6; you need only state that demand can never be satisfied, anyway, because it will expand to fill whatever capacity it is given. Throw in a cynical attitude about the phone companies' ability to lobby for legislation that will help them out, locally and nationally, and you're done.

Messing with time and space

The scenario we find most compelling mixes economic and organic elements to provide sufficient -- if not surplus -- capacity on the average, with occasional dislocations over time and space. It assumes that the Internet-access market remains open and competitive, and that economic incentives continue to direct resources where they're best compensated. The key, though, is the way the Internet takes advantage of time and space.

Time. The Internet doesn't force all traffic to occur in real time. It allows traffic to find the most efficient paths. The range of service options we described will allow low-priority e-mail and Usenet newsgroups to move at the cheapest possible rates, or when the needed links are least congested. Soon Internet providers will allow senders to set and pay for priority status. In contrast, the phone system is designed for real-time communications: For example, faxes, which don't really have to move in real time, currently go that way anyway.

Space. The Internet growth process is organic: Traffic (paying traffic, that is) attracts suppliers, who can install nodes and links where they're needed -- right down to the workgroup or neighborhood.

Great examples of this hyperdistributed capacity exist already in corporate intranets and so-called toasternets. Corporate network administrators'

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3 *Measuring idle ("dark") fiber is tricky, but a 1994 FCC survey of fiber capacity in 1993 indicates that few local or long-distance carriers were using more than half of the capacity at their disposal.*

4 *In its vaunted research labs, IBM has fiber-optic transmission technology that uses higher frequencies and colors (think of them as chords) to move 20 times as many bits as today's technology can.*

full-time job is to balance loads and bring processing power to where it's needed. When they run Internet protocols, they're building the tendrils of the Internet, even if there's no connection to the public Internet. As long as colleagues share information locally, their traffic never goes outside the company's premises. The network is locally self-sufficient.

Toasternets are informal ISPs that generally operate from individuals' basements and kitchens, reselling capacity they buy from larger ISPs. The Little Garden is a regional ISP that started as a toasternet and now resells bandwidth inexpensively to local businesses and other resellers in Silicon Valley.

Today, almost anyone can create such a service and tap into the broader Internet. Just as neighbors sometimes pool funds for a satellite TV dish, soon they might do so for an Internet connection that would primarily allow them to keep audio or video links open between their homes all day. Or they might do it for home security and multi-player games. Note that services can move anywhere. Logical servers can move to where they fit best in network traffic patterns. Or they can break up into modules small and nimble enough to run on individuals' PCs. Think of it as highly scalable load balancing.

Newly fluid markets

As we begin 1996, a real connectivity market is emerging. It's different from the traditional communication markets -- neither as rigid as the phone monopolies nor as closed as the cable TV system. Competition now cuts across markets and territories, as well as up and down the supplier chain. As a result, phone prices will probably drop; Internet access prices will likely rise according to service level as reliability improves and advanced services arrive.

There is a new virtual architecture on top of the physical one that can evolve more rapidly than the physical one, which will require more radical redesign than most carriers currently contemplate so that it better fits the new business models and kinds of traffic that households and businesses will demand.

COMING SOON

- *Intellectual property, Release 2.0.*
- *Visualizing organizations.*
- *Networked object graphics.*
- *Avatars: motion and emotion online.*
- *The analog world.*
- *And much more... (If you know of any good examples of the categories listed above, please let us know.)*

RESOURCES & PHONE NUMBERS

Milo Medin, **@Home**, (415) 833-4950; fax, (415) 421-3128; medin@home.net
Waring Partridge, **AT&T**, (908) 221-5500; fax, (908) 221-2973;
partridge@attmail.com
Cliff Conneighton, **BBN Planet**, (617) 873-4000; cconneig@bbnplanet.com
Bob Lucky, **Bellcore**, (908) 758-2100; fax, (908) 758-4530;
rlucky@bellcore.com
Padmanabhan Srinagesh, **Bellcore**, (201) 829-5233; fax, (201) 829-4325;
nagesh@bellcore.com
Martin Sirbu, **Carnegie-Mellon University**, (412) 268-3436;
sirbu@andrew.cmu.edu
Eli Noam, **Columbia University**, (212) 854-4596; fax, (212) 932-7816;
enoam@research.gsb.columbia.edu
John Gilmore, **Cygnus Support**, (415) 903-1418; gnu@toad.com
James Moore, **GeoPartners**, (617) 492-3600; fax, (617) 492-7822;
jim@geopartners.com
Gerald Brock, **George Washington University**, (202) 994-3989; fax, (202) 994-0022; gbrock@gwis2.circ.gwu.edu
Lee Caldwell, **IBM**, (914) 766-1851; fax, (914) 766-8128; leec@gemini.ibm.com
John Patrick, **IBM**, (914) 766-1090; fax, (914) 766-8128; jrp@vnet.ibm.com
Phil Gross, **MCI**, (703) 715-7431; fax, (703) 272-7066; pgross@mci.net
Bruce Kushnick, **New Networks Institute**, (212) 837-7867; fax, (718) 921-6078
Nicholas Economides, **New York University**, (212) 998-0864;
neconomi@stern.nyu.edu
Stephen Green, **Pacific Bell**, (510) 901-9688; fax, (510) 277-1808;
3548028@mcimail.com
Judy Estrin, **Precept Software**, (408) 446-7600; fax, (408) 446-7610;
jestrin@precept.com
Martin Schoffstall, **PSINet**, (703) 904-4100; fax, (703) 904-4200;
schoff@us.psi.com
Richard H. Miller, **Telematica**, (415) 943-1743; fax, (415) 938-1210;
rmiller@telematica.com
Tom Jennings, **TLGnet**, (415) 487-1902; tomj@tlg.net
Jeff MacKie-Mason, **University of Michigan**, (313) 764-7438; jmm@umich.edu
Hal Varian, **UC Berkeley**, (510) 642-9980; fax, (510) 642-5814;
hal@sims.berkeley.edu

WEB RESOURCES AND FURTHER READING

There are many excellent resources on the economics of the Internet (especially on congestion pricing) on **Jeff MacKie-Mason's** Website at the University of Michigan (http://gopher.econ.lsa.umich.edu/EconInternet/AllSubjects.html) and **Hal Varian's** site at the University of California, Berkeley (http://www.sims.berkeley.edu/resources/infoecon). The two have collaborated for many years; Varian recently moved from U. Michigan to UC Berkeley. NYU's **Nicholas Economides** has written extensively on network externalities and economic models for the Internet (http://edgar.stern.nyu.edu/networks).

George Washington University's **Gerald Brock** wrote a paper on bill-and-keep interexchange arrangements for Teleport Communications Group titled "The Economics of Interconnection" (April 1995; alas, there's no Web version; for a copy, contact Teleport's Christine Grannis at (718) 983-2295). For other views on the stability of bill-and-keep (and matters such as Internet cost

structures and the On Demand Routing protocol), contact Bellcore's **Padmanabhan Srinagesh** (see across).

Finally, two general resources. **The Economist** has a great Web version of its survey, "The accidental superhighway: A survey of the Internet," by Christopher Anderson (July 1, 1995; http://economist.com/internet.htm). And **Jim Moore** (across) of Boston-based consultancy GeoPartners has just finished a book titled **The Death of Competition: Leadership and Strategy in the Age of Business Ecosystems**, available this spring from HarperCollins.

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RELEASE 1.0 CALENDAR

January 5-8	**Winter Consumer Electronics Show** - Las Vegas. Organized by the EIA. What comes after 64 bits? Call Cynthia Upson, (703) 907-7674; fax, (708) 203-1996.
January 9	**Boosting Collective IQ** - Washington, DC. Organized by the Bootstrap Institute. See Doug Engelbart's vision unfold. Call (510) 713-3550; fax, (510) 792-3506; info@bootstrap.org.
January 9-12	**Internet World Canada '96** - Toronto. Organized by Mecklermedia and Computing Canada. Call (203) 226-6967 or (800) 632-5537; fax, (203) 226-6967; iwcanconf@mecklermedia.com; http://www.mecklermedia.com/shows.
January 9-12	**MacWorld Expo 1996** - San Francisco. Sponsored by Macworld and San Francisco Chronicle. See CyberDog do its tricks. Call Krishna Luippold, (617) 440-2742; fax, (617) 440-0300; http://www.mha.com/macworldexpo.
January 10-12	**Networked Multimedia and Global Business** - Menlo Park, CA. Organized by SRI International. Call Suzanne Erne, (415) 859-6140; fax, (415) 859-6030.
January 14-16	**ISA's Annual Strategic Business Meeting** - Miami. Sponsored by the Interactive Services Association. Call Patti S. McKnight, (301) 495-4955; fax, (301) 495-4959; ISA@isa.net.
January 17-19	**RSA Data Security Conference** - San Francisco. Sponsored by RSA. Bring your prime-number decoder rings. Call Kurt Stammberger, (415) 595-8782 or (415) 340-9300; fax, (415) 340-9292; layne@lke.com.
January 18-19	**Online Strategies for Book Publishers** - New York City. Organized by AIC Conferences. Call Gregory Kaplan, (212) 952-1899 or (800) 409-4242; fax, (212) 248-7374.
January 21-25	**Lotusphere '96** - Walt Disney World Resort, FL. Sponsored by Lotus/IBM. Call Mike Austin, (617) 894-5326 or (800) 655-6887; fax, (617) 899-2099; http://www.lotus.com.
January 22-23	**Multimedia Market West** - Beverly Hills, CA. Sponsored by KPMG Peat Marwick and The Red Herring. Call Jill Madden, (415) 865-2277 x211; fax, (415) 865-0453; events@herring.com; http://www.herring.com.
January 25-26	**Fourth Annual Conference on Communications and Media Finance** - New York City. Organized by Institute for International Research. Call Douglas Campbell, (800) 999-3123 or (212) 661-3500; fax, (212) 661-6677.
January 25-26	**Firewalls and Internet Security Conference '96** - Arlington, VA. Organized by National Computer Security Association. Call Kim Imler, (717) 258-1816 x226 ; fax, (717) 243-8642; firewallcon@ncsa.com; http://www.ncsa.com.
January 28-31	**Demo '96** - Palm Springs, CA. Co-sponsored by Intel and Novell. Dave Coursey's picks. Call Demo registrar, (800) 633-4312; fax, (415) 286-2750; 4477851@mcimail.com.
January 29-30	**Business-To-Business Marketing on the Internet** - San Francisco. Sponsored by IIR. Call Mikki Glass, (212) 661-8740 or (800) 999-3123; fax, (212) 661-6677 or (800) 959-9644; http://and.com/iir.

January 30-31	**Managing the Digital Document '96** - San Francisco. Sponsored by AIIM. Call Kara Dao, (800) 477-2446 x604 or (800) 990-2446; fax, (301) 588-4838 or (301) 565-2230.
January 30	**The Internet & World Wide Web Information Conference** - New York City. Organized by National Seminars Group. Call Dan Bohlken, (800) 682-5078; fax, (913) 432-0824; info@natsem.com.
Jan 29 - Feb 1	**@EurOpen - Publishing on the Internet** - Zurich and Stockholm, two days each. Sponsored by The European Forum for Open Systems. With Jerry Michalski. Call EurOpen Secretariat, 44 (1763) 273039; fax, 44 (1763) 273255; europen@eu.net.
Jan 29 - Feb 1	**ComNet '96** - Washington D.C. Organized by Mitch Hall Associates. Call Mary Kindel, (617) 440-2718; fax, (617) 440-0357; http://www.mha.com/comnet.
Jan 30 - Feb 1	**SoftExpo '96** - Santa Clara, CA. Sponsored by Software Publisher Magazine. Call John Cargile, (303) 745-5711 or (800) 803-9488; fax, (303) 745-5712.
Jan 31 - Feb 1	**1996 Interactive Information Venture Forum** - New York City. Sponsored by Information Industry Association. Call Andrea Petersen, (202) 639-8260; fax, (202) 638-4403.
February 4-7	**Business Process & Workflow '96** - Lake Buena Vista, FL. Sponsored by BIS Strategic Decisions. Call Scott Washburn, (617) 982-9500; fax (617) 878-6650; swashburn@gigasd.com.
February 5-6	**EMA Client-Server Messaging Forum** - Washington, DC. Organized by the Electronic Messaging Association. Call (703) 524-5550; fax (703) 524-5558; meet@ema.org; www.ema.org/ema.
February 5-7	**EMA Public Policy Forum** - Washington, DC. Organized by the EMA. Call (703) 524-5550; fax (703) 524-5558; meet@ema.org; www.ema.org/ema.
February 9-12	**Milia '96** - Cannes, France. Sponsored by Reed Midem. Call Caroline Dattner, 33 (1) 44-34-44-94; fax 33 (1) 44-34-44-00, or Donna Shelton, (404) 897-2300; fax, (404) 897-2311.
February 13-14	**The Online Advantage** - Bellevue, WA. Sponsored by Digital Media Alliance and the Washington Software Association. With Esther Dyson, Ted Leonsis and Stanley Marcus (yes, the chairman emeritus of Nieman-Marcus). Call Michele Ruegg, (206) 450-9965; fax, (206) 889-8014; Mruegg@ aol.com; to register call (206) 889-8880; www.wsa.com/wsa/ events/ola96.
February 13-15	**Virtual Reality World '96** - Stuttgart, Germany. Sponsored by IDG. Call Caroline Dattner, 49 (89) 36086-390; fax, 49 (89) 36086-274; vrw.idg@iao.fhg.de.
February 13-15	**Networks Expo Boston '96** - Boston. Organized by Blenheim Group. Call Annie Scully, (800) 829-3976 x145; fax, (201) 346-1532; ascully@blenheim.com; http://www.shownet.com.
February 13-16	**Wireless Technologies Mexico '96** - Mexico City, Mexico. Organized by E.J. Krause & Associates, Inc. Call Tobey Sommer, (301) 986-7800; fax, (301) 986-4538.
February 14-20	**1996 ACM Computing Week** - Philadelphia. Sponsored by ACM. Events for all interests from the oldest surviving computing association. Call Donna Baglio, (212) 626-0606; fax, (212) 302-9610; baglio@acm.org.
February 18-20	**Mobile Insights '96** - Phoenix. Organized by Mobile Computing Insights. Jerry Purdy's show. Call Julie O'Grady, (408) 777-4868; fax, (408) 253-6608.
February 20	**A Nation Connected: Defining the Public Interest in the Information Superhighway** - Rancho Mirage, CA. Organized by

	American Library Association. With Esther Dyson. Call Barbara Macikas, (312) 280-3201, fax (312) 280-3256.
February 20-22	**Digital Hollywood: The Media Marketplace** - Los Angeles. Organized by American Expositions. Call (212) 226-4141; fax, (212) 226-4983; www.digitalhollywood.com.
February 21-24	***Interactive Newspapers '96** - San Francisco. Sponsored by the Kelsey Group, Editor & Publisher and INMA. With Esther Dyson. Call Natalie Kaye, (609) 921-7200; fax, (609) 921-2112; http://www.kelseygroup.com/kelsey.
February 21-24	***TEDSELL** - Monterey, CA. Organized by TED Conferences. With Esther Dyson. Call David Sume, (401) 848-2299; fax, (401) 848-2599; wurman@media.mit.edu.
February 26-28	**Consumer Online Services III** - New York City. Organized by Jupiter Communications. Call David Schwartz, (212) 780-6060; fax, (212) 780-6075; http://www.jup.com.
March 2-6	**1996 Spring Symposium** - San Francisco. Presented by the Software Publisher's Association. Call Nadia Kader, (202) 452-1600 x339; fax, (202) 223-8756; nkader@spa.org.
March 4-5	**Inside the Yellow Pages '96** - La Jolla, CA. Organized by SIMBA Information. Call Bill MacRae, (203) 834-0033 x160; fax, (203) 834-1771; simbainfo@simbanet.com.
March 4-7	**intermediaWORLD '96** - San Francisco. Organized by Reed Exhibition Companies. Call (203) 840-5634 or (800) 246-8371; fax, (214) 466-4611; imworld@reedexpo.com; www.reedexpo.com.
March 14-20	**CeBIT Hannover '96** - Hannover, Germany. Sponsored by Deutsche Messe AG. Take comfy shoes. Call Mette Peterson, (609) 987-1202; fax, (609) 987-0092.
March 17-20	****1996 PC (Platforms for Communication) Forum: The Future Now (some assembly required)** - Tucson, AZ. Sponsored by us: You read the newsletter; now meet the players. See page 21 for a preview. Call Daphne Kis, (212) 924-8800; fax, (212) 924-0240; daphne@edventure.com.
March 17-20	**Interactive Entertainment Congress '96** - Palm Springs, CA. Sponsored by Institute for International Research. Call Dana Shibley, (212) 661-3500 x3273 or (800) 999-3123; fax, (800) 959-9644; us002506@interramp.com.
March 18-22	**BrainShare '96** - Salt Lake City. Novell's annual developer conference. Call (314) 287-5259 or (800) 833-4862 x33; http://BrainShare.novell.com.
March 19-23	**CSUN's Conference on Technology and Persons with Disabilities** - Los Angeles. Sponsored by California State University, Northridge. Call Dr. Harry J. Murphy, (818) 885-2578; fax, (818) 885-4929; ltm@csun.edu.
March 27-30	***The Sixth Conference on Computers, Freedom and Privacy '96** - Cambridge, MA. Hosted by MIT and the World Wide Web Consortium. Watch hackers, feds and business folks discuss things calmly. Call Marie Seamon, (617) 253-1700; fax, (617) 253-7002; http://web.mit.edu/cfp96.

** Events Esther plans to attend.*
@ Events Jerry plans to attend.

Lack of a symbol is no indication of lack of merit.
Please let us know about other events we should include. -- Christy Snipp

1996 PC FORUM PREVIEW

It's the day after Christmas. The children are in paroxysms of delight. The floor is littered with shiny new toys, spare parts, wrapping paper, unopened cards from well-meaning distant relatives. Overlooking it all is Teddy the Bear, who has survived many Christmases unscathed.

About all these toys: How can we get them to work? Are the parts all there? Everything looks great, but nothing works together. The batteries Dad bought on sale last summer, with great foresight, have already gone dead. No one can figure out how to assemble the kitchen robot; the instructions are inscrutable, and maybe a part is missing; it's impossible to tell. Dad is an old hand at this; he actually gets one of Junior's toys to work, but he can't figure out what it does. Junior grabs it from him; it breaks.

....now it's February. The electronics are forgotten; the video has lost its charm; the talking doll has permanent laryngitis. But Teddy stays on. He's a source of comfort, a witness to events, a steady friend in a changing world. The children are playing with Teddy and with the sled; the electronic toys are in the basement. And in the mailbox: the credit-card bills.

Sound like any business you know?

Each **Release 1.0** subscription (plus a fee!) entitles you to two registrations to the 19th annual PC (Platforms for Communication) Forum, March 17 to 20, in Tucson, Arizona.

The theme this year is **"The Future Now (some assembly required)."**

The age of online and multimedia is upon us. Computers that aren't connected aren't part of the picture. The development platform is not the mainframe or the pc, but the network. Businesses are setting up Web sites; content companies and search services are going public at astronomical P/E ratios; companies are merging and divesting with abandon. But it's not clear that any of these pieces will actually work together, or that they're plugged into a steady power source -- profitability.

Online technology and services are opening up a new world, but like the kids at Christmastime, we face a number of questions before we can get the toys to work. What's a keeper, and what should we give to cousin Fred?

- *interoperability and openness.* Do the dolls fit in the dollhouse? Do the trains run on the tracks? How can we get all these services and products to work together? Consumers won't stand for payment systems that don't let them pay all their bills from one service. Content providers don't want to reformat their content for the standards of different services.

- *playing with the toys.* What will these toys and tools let us do? Will teenagers decorate their home pages as they now decorate their rooms? How will consumers actually spend their time and increasingly scarce attention? How will businesses operate when everyone's connected all the time, everywhere?

- *rebellious toys.* What happens when the toys get minds of their own? What will happen when agents -- some of them distinguishable from viruses only by attitude -- roam the Net? How will they interact? How can we ensure system integrity?

- *the bullies down the street.* Will we be able to keep our toys, or will the rich bully grab them away? Is the online world really a new kind of market where diversity rather than standards will reign?

- *sharing with other children.* Do all these mergers make sense? The behemoths are all buying content companies, sure such alliances will ensure their futures, while content companies are looking for distribution and access. Is it worth it to own a content company? Content wants to find its way to all consumers; delivery media want to deliver all content. Exclusives are no longer bottlenecks that allow an owner to charge a toll; they're detours that will be bypassed in the long run.

- *parental control.* Who's going to control the Net? Like it or not, the government wants a say. But commerce won't move onto the Net without strong security, and international commerce will be tough without global agreements on standards for intellectual property, authentication and the like. Meanwhile, how will governments (such as Germany!) react to a world that ignores traditional national borders?

- *lemonade stand or allowance.* Will we get paid for content or for intellectual services around content -- searching, reliable delivery (subscriptions), consulting, performances, authentication, exchange and brokerage services? Will advertisers pay for it all? Who gets to keep the revenues?

- *the bills.* Are telcos ignoring the economics of the Internet just as the mainframe vendors of old ignored the economics of PCs? (See the bulk of this issue.) In the long run, the Internet brings economies of scale down to small players -- whether customers or providers. Anyone can afford to be a provider; anyone can market his goods worldwide.

Join us next March in Tucson, where we'll consider all these questions. Seriously...

We'll have speeches and panels, debates and audience interaction. We also plan a special roundtable with the consumers of the future -- your children.

We'll also have presentations from interesting new companies such as Connect, the Electronic Rights Management Group, OnLive!, GNN, Net Objects,

Saqqara Systems and Worlds plus our own Rumpus Room full of "future now" products and services organized by Jerry Michalski.

We hope to see you there, along with the "future now" customers -- your families.

Speakers will include:

Jim Barksdale, Netscape
Steve Case, America Online
Scott Cook, Intuit
Anthea Disney, News Corp./MCI Online Ventures
John B. Evans, R.E.M. Productions
Bran Ferren, Walt Disney Imagineering
Bob Frankenberg, Novell
Frank Fukuyama, Rand Corporation, author of *Trust*
Bill Joy, Sun Microsystems
Jerry Kaplan, Onsale
Will Hearst, @Home
Ray Lane, Oracle
Alex Mandl, AT&T
Robert Massey, CompuServe
Bert Roberts, MCI
Ray Smith, Bell Atlantic
Lee Stein, First Virtual Holdings
Mike Zisman, Lotus/IBM

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